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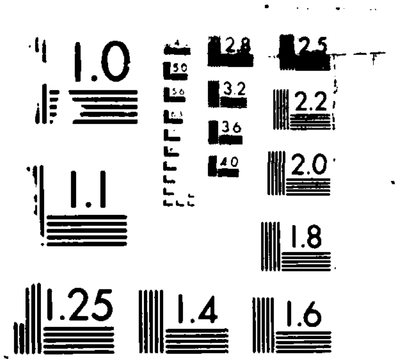

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Development of a frazil ice sampler

Bruce E. Brockett and Paul V. Sellmann

Prepared for
OFFICE OF THE CHIEF OF ENGINEERS

For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380, Metric Practice Guide, *published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.*

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A lightweight sampler has been constructed to provide large cores from frazil ice deposits. Samples containing frazil ice particles ranging in size from 1 mm to over 70 mm, including the interstitial water, were successfully recovered during field tests. These samples were nearly undisturbed while confined in the sample tube, based on a comparison with samples acquired using a freeze probe technique.

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PREFACE

This report was prepared by Bruce E. Brockett, Physical Science Technician, Geological Sciences Branch, Research Division, and Paul V. Sellmann, Geologist, Geotechnical Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. The research was funded in part under DA Project 4A762730AT42, Design, Construction, and Operations Technology for Cold Regions, Task CS, Work Unit 035, Drilling Technology for Cold Regions. This is one of a series of informal reports that deal with drill design, drill fabrication and methods for drilling and sampling in ice and frozen ground.

The authors thank Herbert Ueda and John Rand of CRREL for reviewing this report. They also thank Fred Gernhard for helping build the sampler.

The contents of this report are not to be used for advertising or promotional purposes. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

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DEVELOPMENT OF A FRAZIL ICE SAMPLER

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INTRODUCTION

This sampler was designed and constructed in response to a request from CRREL investigators conducting field research on the Tanana River. Their need was to acquire samples of frazil ice beneath the river's ice cover. This frazil ice occurs as deposits similar to a hanging dam or is continuous from the base of the ice cover to the riverbed (Fig. 1). The ice particles composing these deposits range in size from 1 mm to over 70 mm, and the interstitial water contains a high concentration of sediment. Previous efforts made by the researchers to sample the frazil deposits using a CRREL 2-in. frazil ice sampler (Rand 1982) were unsuccessful, primarily because of the large size of the ice particles. However, these efforts did

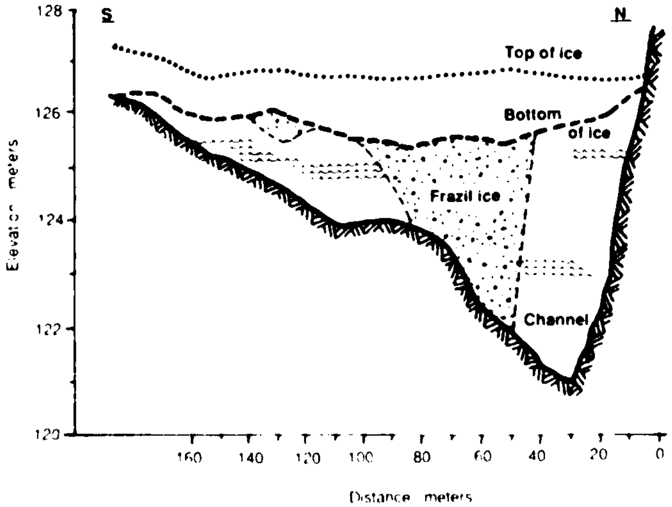


Figure 1. Frazil ice beneath an ice cover, both a small hanging deposit and a larger continuous deposit. This cross section is from the Tanana River. (From Chacho et al. 1986.)

indicate that a thin-walled sampler could be pushed into this material with little difficulty. Winter operations require that the sampler be workable under wet and cold conditions that could cause icing of working parts.

APPROACH

A list of specifications were developed for the sampler to guide the design effort. These parameters were considered important:

- A positive closure at the base of the sample tube is necessary for retaining all interstitial water and small ice particles.
- The closure must be made when particles as large as 70 mm occur at the closure point.
- The sampler must be lightweight and durable.
- The design must be simple to reduce freeze-up and icing problems.
- The sampler must be fitted with extensions for sampling beneath ice covers ranging from 1 to 5 ft thick (0.3-1.6 m).
- Sample recovery at the surface must be rapid since frazil ice particles would be modified by additional freezing.
- The sampling technique should cause minimal disturbance to the sample.

The two most important features of the new sampler are 1) a large diameter in relation to particle size and 2) a positive closure to prevent the loss of water. Common mechanical closure techniques (trap doors and flap valves) were not considered because a positive seat could not be ensured. Commercial products were considered but none were found that would meet these criteria.

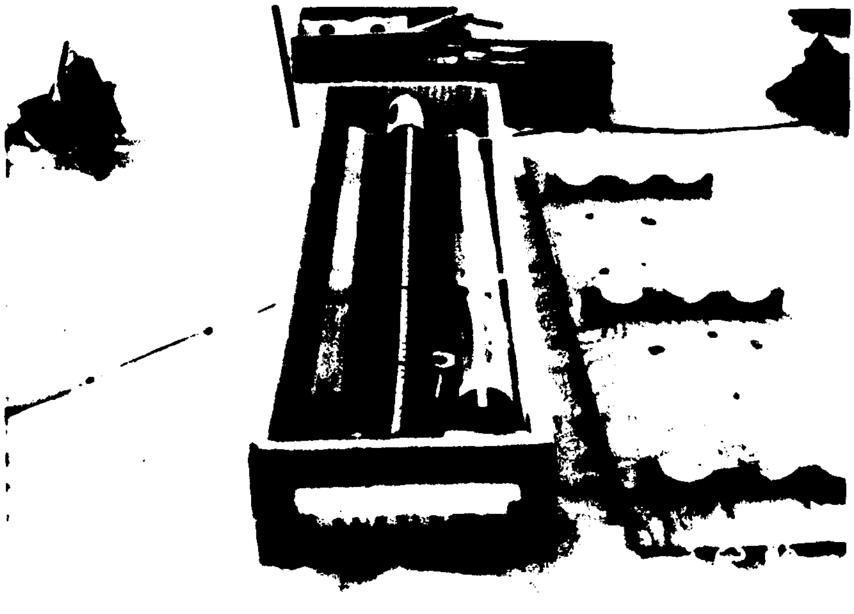
DESIGN OF THE SAMPLER

The sample tube on the first CRREL frazil sampler (Rand 1982) is closed just above the cutting head by constricting a rubber membrane with a coiled string pulled from the surface. Closure of a rubber membrane is also used as a core catcher on the Gemware Improved Core Cutter Head, where the membrane is closed by partial rotation of an inner core sample tube. A spring mechanism is remotely tripped, rotating the inner tube approximately 180°. A flexible membrane closure seemed ideal for the new sampler. Several tests, using a mixture of ice cubes, crushed ice, snow slush and water, were conducted in the laboratory to determine the influence of particle size on closure of a flexible membrane. These tests demonstrated that large particles prevented a membrane from closing adequately with a single rotation (360°). It was found, however, that three rotations of the membrane created a positive seal, even with large particles included in the twist.

The membrane concept and a simple means of rotating the inner sample tube were used in the prototype sampler. The sampler is shown in Figure 2.

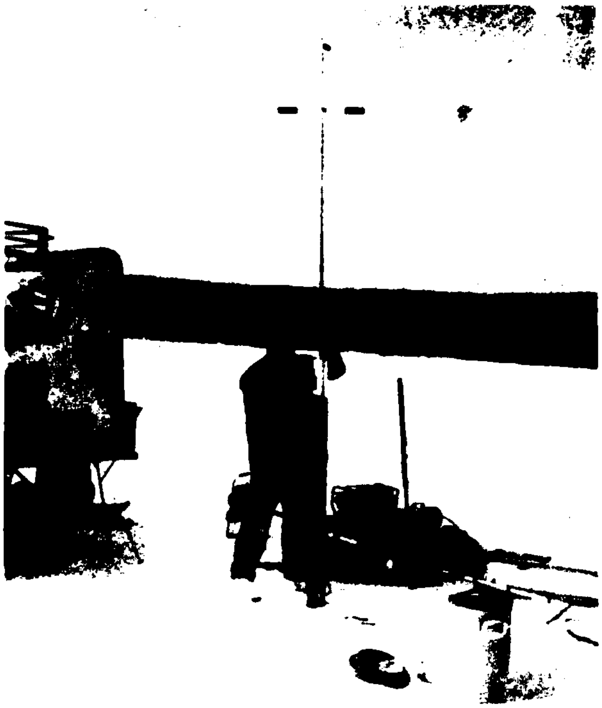
To keep the sampler's weight to a minimum, aluminum and plastic are used for all parts except the cutting shoe, which is mild steel. Also, to reduce overall costs, components and stock were selected that needed very little machining. For example, prethreaded steel casing was selected for construction of the removable cutting shoe. The outer and inner tubes of the sampler are standard stock selected to provide sufficient tolerance for attachment of components and ease of operation.

The sampler consists of an inner sample tube made of clear plastic and an outer tube of reinforced fiberglass pipe (Fig. 3) sufficiently strong to



a. Shipping container with the disassembled prototype sampler.

Figure 2. The frazil ice sampler.



b. Sampler in use at the Tanana River study site. The ice cover is 1.5 m thick.

Figure 2 (cont'd). The frazil ice sampler.

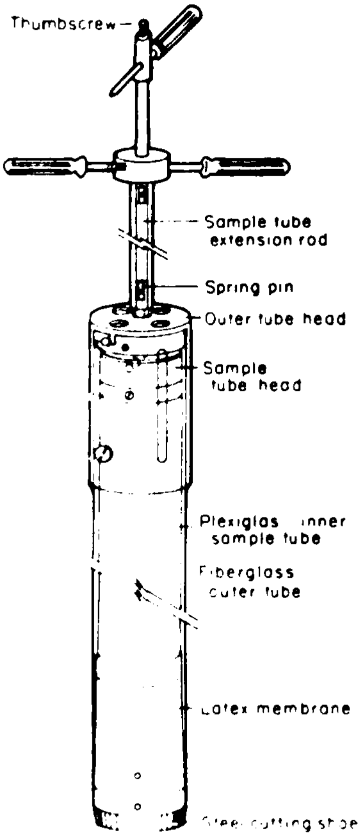


Figure 3. Parts of the sampler.

handle the forces associated with sampling. The cutting shoe is attached to the outer tube and is tapered to a sharp edge. Atop the outer tube is an aluminum sleeve to which the head, extension rods and a handle attach. The sampler is designed to be pushed into the frazil; it does not rely on rotation for penetration.

The head of the Plexiglas sample tube is connected to extension rods that fit inside the outer tube extension rods and handle, providing an easy method for securing and rotating the inner tube, thus twisting and closing the membrane (Fig. 4).

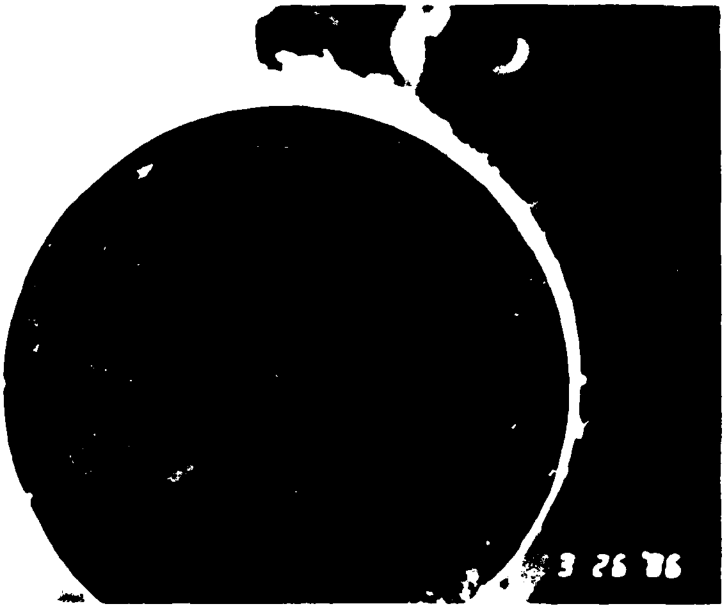
The various components of the sampler are described in Appendix A, and the sampling procedures are described in Appendix B.

FIELD TESTS

The sampler was evaluated under field conditions at a CRREL study site located at the confluence of the Tanana and Chena rivers, near Fairbanks, Alaska, where thick deposits of frazil ice are found.

a. Membrane in the open position.

Figure 4. Latex membrane.



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b. Membrane twisted closed after three revolutions of the sample tube.

Figure 4 (cont'd). Latex membrane.

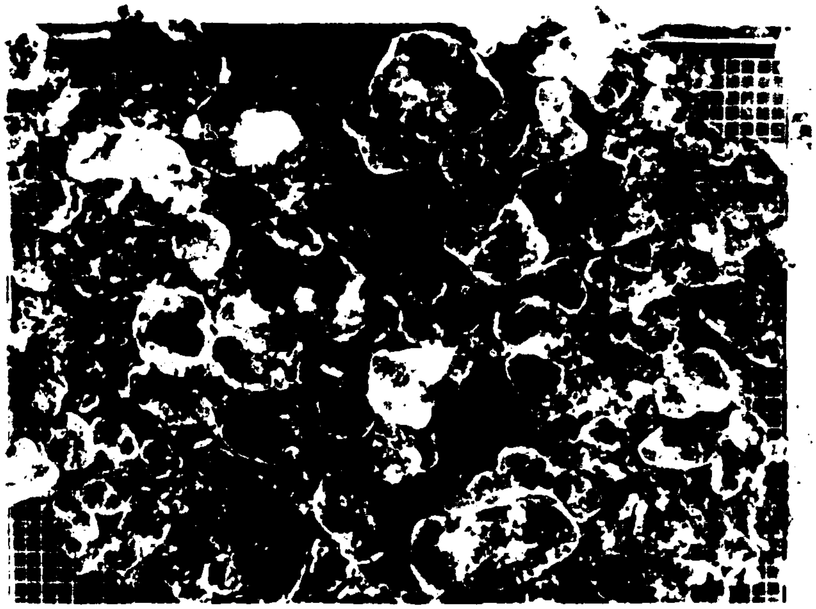
Eight locations were selected to evaluate the sampler under a variety of conditions, including

- Deposits with uniform particle size,
- Deposits with layers of different particle sizes,
- Hanging deposits with open water beneath, and
- Continuous deposits that extended to the riverbed.

In each case the frazil ice was successfully sampled (Fig. 5). The interstitial water drained from only one sample of uniformly distributed 1- to 4-mm-size particles. The in-place density of this material was great enough so that there was not enough void space for the ice particles to be completely displaced at the point of closure when the membrane was rotated. The ice, however, was fully recovered.

The quality of each sample was determined by comparison with freeze probe samples. This method is fully described in Chacho et al. (in prep.). These comparisons demonstrate that this frazil ice sampler does not compact or reorient the frazil particles during sampling. Also, the interstitial water with suspended sediments is basically undisturbed. Removal of the sample in the field, however, will reorient the particles and mix the water.

a. Sample tube containing a typical sample from a hanging frazil ice deposit.



b. Example of frazil ice particles recovered during field evaluation of the prototype sampler. They are shown on a grid of 1-cm squares.

Figure 5. Results of sampling.

Sampling operations were conducted while air temperatures were well below the freezing point, but this caused no significant problems. Only minor icing of the sampler occurred, and this was readily dealt with by heating the iced-up or frozen parts. A small heat gun or larger hot air heater is an important accessory for this type of work.

CONCLUSIONS

Laboratory and field tests have shown that this frazil ice sampler is capable of obtaining a nearly undisturbed bulk sample from frazil ice deposits, including interstitial water.

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Chacho, E.F. Jr., B.E. Brockett and D.E. Lawson (in prep.) A fast-freeze approach to sampling frazil ice deposits. U.S. Army Cold Regions Research and Engineering Laboratory, Special Report.

Chacho, E.F. Jr., D.E. Lawson and B.E. Brockett (1986) Frazil ice pebbles: Frazil ice aggregates in the Tanana River near Fairbanks, Alaska. Proceedings, IAHR Ice Symposium 1986, Iowa City, Iowa, pp. 475-483.

APPENDIX A: MATERIALS

1. 4-1/2 in. O.D. x 4 in. I.D. HR wireline casing, flush joint with a four-thread pattern in 1-ft lengths.
2. 4-1/2 in. O.D. x 1/10 in. wall fiberglass pipe in 5-ft lengths.
3. 4-1/8 O.D. by 3-7/8 in. I.D. Plexiglas tube in 6-ft random lengths.
4. 4 in. diam. x 12 in. long x 0.025 in. thick latex membrane.
5. 4-3/4 in. O.D. x 0.250 in. wall aluminum tubing.
6. 1.315 in. O.D. x 0.179 in. wall, schedule 80 aluminum pipe.
7. 3/4 in. O.D. x 0.650 in. I.D. stainless steel tubing.
8. Spanner wrenches, two each.
9. Screwdriver, straight blade, 6 in. long.

APPENDIX B - DETAILED SAMPLING PROCEDURES

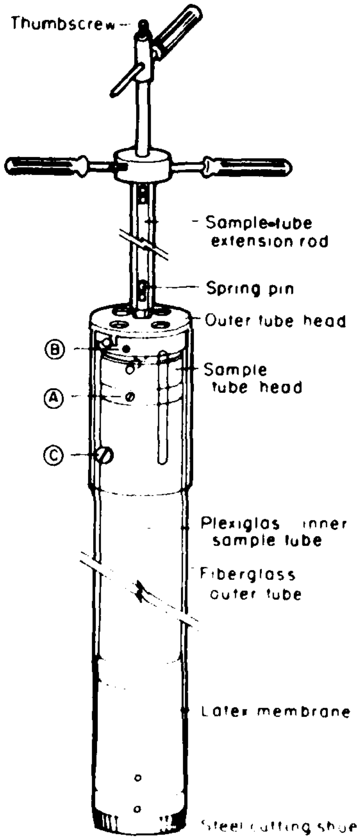
SAMPLER ASSEMBLY

1. Insert the sample tube head (Fig. B1) into the Plexiglas sample tube and back out the plastic screw (A) until flush with the outside of the sample tube.

2. With the cutting shoe removed, insert the Plexiglas tube into the fiberglass tube and stretch the membrane over the outside of the threaded steel insert until the end of the folded-back membrane is in contact with the first thread.

3. After retracting the Plexiglas tube to straighten the membrane, screw on the cutting shoe. Tighten with the spanner wrenches.

4. With the handles and extension rods assembled, but without the outer tube head attached, snap on the sample-tube extension rod, insert the outer tube head and back out the setscrew (B).



(A) Sample tube head setscrew

(B) Outer tube head setscrew

(C) Aluminum sleeve setscrew

Figure B1. Frazil ice sampler and locations of the operational components.

5. Insert the screwdriver into the nipple atop the sample-tube extension rod and secure with the thumb screw.

6. Pull the sample tube upward until the membrane is taut and straight (Fig. 4a). Screw in the handle until the sample-tube extension rod is secured.

SAMPLING TECHNIQUE

After pushing the sampler into the frazil ice deposit, follow these steps to close the sampler and recover the sample:

1. Unscrew the handle, freeing the sample-tube extension rod, and rotate the screwdriver three revolutions; then resecure the sample-tube extension rod and remove the screwdriver.
2. Lift the sampler up until setscrew C in the aluminum sleeve is accessible; tighten the screw, securing the sample tube (do not overtighten).
3. Loosen the handle, freeing the sample-tube extension rod, and remove the outer tube head. Unsnap the sample-tube extension rod and set the assembly aside.
4. Lift the sampler free of the hole. While holding the sample tube head firmly to prevent the membrane from untwisting, loosen setscrew C.
5. While the sample tube is held from above, hold onto the membrane through the open end of the shoe, remove the shoe, tie off the twisted membrane with a wire tie, and extract the sample tube from the outer tube.
6. Remove the sample tube head.

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